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Virtual Signal Generator for Flicker Modeling with GUI

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Abstract – This paper describes an implementation method of a virtual signal generator for flicker modeling, with graphical user interface, build in Matlab environment using an integrated codec or a sound card, the advantages and the disadvantages of this solution, in the actual context of increasing of the interest for ensure power quality.
Keywords: flicker, power quality, electromagnetic compatibility, sound card.

I. INTRODUCTION

In the last decades the number of non-linear loads has increased and consequently have increased also the electromagnetic compatibility problems and implicit power quality problems, which affect many industries. Simultaneous development of suppliers, competition on market, increase of studies in this field, customers better informed about power quality led to higher requirements for power quality in present.
By electromagnetic compatibility (EMC) it is understood the capability of an equipment or system to operate without emitting electromagnetic disturbances with intolerable levels for anything from its ambiency [4], [5], [12], [14].
Power quality assurance is related to power delivery without interruption of sinusoidal voltage with the amplitude and frequency maintained between certain tolerances determined by standards [5], [8], [12]. For this purpose are used power quality indicators which grant measuring and evaluation of quality level in a certain point of the power supply network at a certain moment. International standards exist and are used in elaboration of national standards. If in the past power quality was the ability to deliver electric power without interruptions, in present due to elements presented before customers requirements are higher than ever before [9].
The flicker is one of the categories of disturbances which may affect the quality of electrical energy supply.
At present most of computer mainboards have integrated codecs or sound card which may be used as a cheaper alternative (probably the cheapest) at the data acquisition boards and may be used successfully for generating of sags disturbances with the help of a software application with a friendly graphic user interface.

II. FLICKER CLASSIFICATIONS AND MODELING

The flicker represents brightness fluctuations of lamps caused by low frequency magnitude variations of power supply voltage. It is present since the beginning of power distribution systems. The flicker effect on humans is cumulative. Severity is appreciated function of human eyes discomfort, long-term flicker causes eye tiredness, vision problems (the consequences could be reduced concentration levels, deterioration in work quality and accidents) or even epileptic seizures. Precision electronic equipments suffer a negative influence. Possible sources are: electrical motor starting, arc furnaces, condenser batteries, welding installations, compressors, starting of high power motors and small loads like starting of induction motors, boilers, power regulators, electric saws and hammers, pumps and compressors, cranes and elevators, sometimes low-frequency voltage interharmonics.
One of the main sources of flickers are the electric arc furnaces (EAF), used in steel plants, because the arc resistances have non-linear variations during melting process.
Usually the main aspect in study of electromagnetic disturbance is the effect on equipment, but in the case of flicker the effect on human has priority. A disadvantage is the individual response to flicker, which is different from one person to another. Same thing appears for lamp type: florescent lamps are more sensitive to frequency flicker than incandescent lamps, but the amplitude of response is smaller [10].
IEC1000-3 standard, elaborated by International Electrotechnical Commission, establish the test approach to flicker for devices and is complex due it try to reduce the variables frequency, amplitude, duration and human response to a single numerical value. If a device pass the test is not guaranteed that it will not cause problems in any conditions, but the obtained results are useful for comparisons with other devices.

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The eye-brain set perceives the flicker if its frequence is inside the range from 0.5 Hz to 25 Hz and the sensitivity is a function of frequency [2]. Frequencies bellow 0.5 Hz are not annoying. The maximum flicker frequency depends on environment illumination and is around 30 Hz. If the frequence is higher than 30 Hz the eye-brain set perceives continuous light. The human eye is very sensitive to light level, even variations in brightness of less than 1% are detected. In the figure 1 [11] is presented the flicker perception threshold for smooth sinusoidal variations and square waves. First category is less perceptible, especially at low frequency. Around the peak sensitivity at 8.8 Hz are perceived voltage variations of 0.2 %. Second category has a similar response for medium to high frequencies and the sensitivity is little higher.

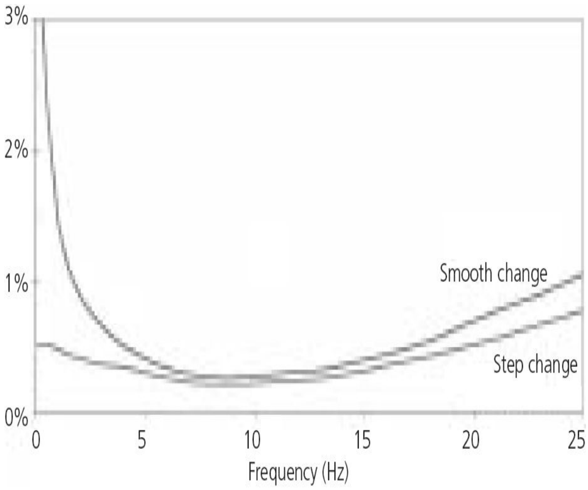


Figure 1. Flicker perception threshold

Measurement of flicker parameters (amplitude and frequency) is an actual problem in power quality, the algorithms used include: the Continuous Wavelet Transform (CWT), Fast Fourier Transform (FFT) and a low pass digital filter, Kalman filtering, least absolute value static estimation and Hilbert Transform [1].

The UIE (International Union for Electricity Applications) established the methodology for flicker measurement [2], adopted by international community. The effect of flicker is a function of intensity of perception and duration of exposure. For severity characterization are used two parameters: short time severity (P_{st}) and long term severity (P_{lt}).

The EN 5060 standard establish that

$$P_{lt} \leq 1 \tag{1}$$

for 95% of measured values doing an statistical analysis on a observation period of one week, inclusive Saturday and Sunday. The units for P_{st} and P_{lt} are perceptibily units (p.u.). The requirements of instrumentation for flicker measurement were established by IEC (International Electrotechnical Commission). The IEC flickermeter [7] is composed from two main components: the first is an electrical model of lamp-eye-brain link which represents the connection between voltage magnitude variations and flicker sensation, used to measure the instantaneous flicker level (IFL), and the second for online statistical evaluation of the IFL used to obtain the value of short time flicker severity (P_{st}).

For flickers modeling can be used the next formula [1]

$$v(t) = \{A_0 + \sum_{i=1}^{M} A_i \cos(\omega_{fi} t + \phi_{fi})\} \cos(\omega_0 t + \phi_0)$$

(2)

where A_0 is the amplitude of nominal power system voltage, ω_0 is nominal power frequency, ϕ_0 is nominal phase angle, A_i is the amplitude of the flicker voltage, ω_{fi} it is frequency, ϕ_{fi} its phase angle and M is the expected number of flickers. The signal $v(t)$ is called amplitude modulation signal.

The signal $v(t)$ can have a sinusoidal variation or a square variation.

III. THE DISCRETE FOURIER TRANSFORM

The Discrete Fourier Transform (DFT) grants frequency domain analysis of discrete periodic signals, for such a signal *x[n]* with finite length *N* the transform is defined according to next relation

$$X(k) = \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{N}kn} \tag{3}$$

where *k=0,1,...,N-1*.

For the input signal *x[n]*, if the number of samples *N* is power of 2, it can be applied FFT (Fast Fourier Transform) algorithm and the advantage is decrease of operations number and implicit of calculation time. The use of this transform for signals on which are overlapped electromagnetic disturbances relieves modifications of spectral components of initial signals due to disturbances.

IV. GRAPHICAL USER INTERFACE AND EXPERIMENTAL RESULTS

In the next figure are presented the elements of graphical user interface, each one has attached a suggestive label. The left part contains two elements for the visualization of output signal and FFT. The rest of the elements are situated in the right side and grant: loading of data file with a recorded disturbed signal, saving a profile file in ASCII format which contains file name and parameters values inserted by keyboard, opening or loading of a profile file, inserting the parameters of the sinusoidal signal (number of desired periods, sampling frequency and visualization of sampling frequency range), over which may be overlapped a voltage flicker disturbance beginning at a specified start sample, inserting desired parameters (amplitude, frequency and number of flicker periods) and selection of type (sinusoidal or rectangular). The area from right down corner (control) allows data refresh, starting/stopping of the sound card and the closing of the application.

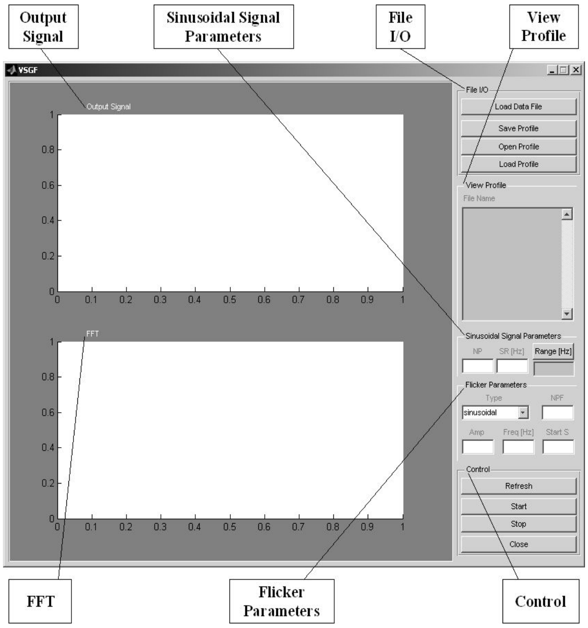
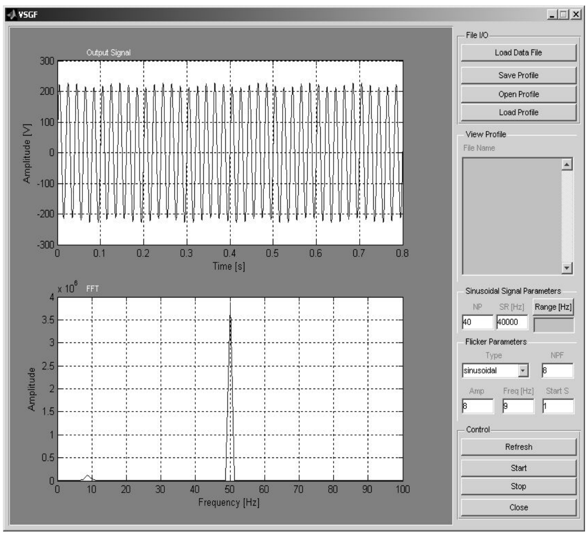
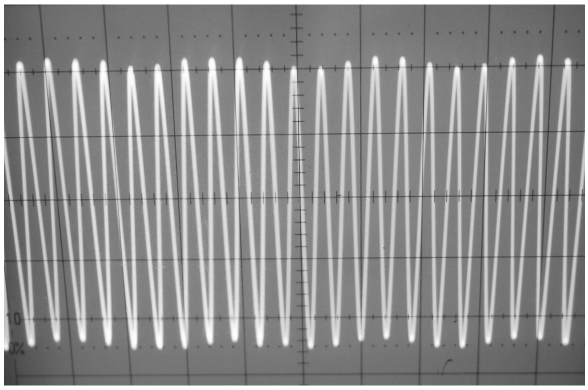


Figure 2. Elements of graphical user interface

The sinusoidal signal disturbed with a flicker from figure 3 it is obtained by using parameters sampling frequency and number of periods with values 44000 and 40, for flicker the type is sinusoidal and amplitude, frequency, start sample and number of flicker periods are 8, 9, 1 and 8.
The spectrum of this signal contains a main peak due to the sinusoidal signal and a second small peak caused by presence of flicker.



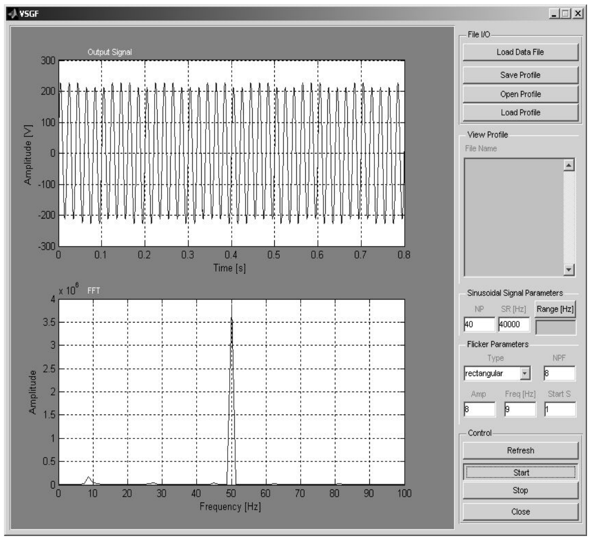
a)



b)

Figure 3. Signal with sinusoidal variation

Parameters values used to obtain the signal from figure 4 are the same like in previous case, the only difference is flicker type, rectangular here. The spectrum of signal contains more small peaks, as in previous case, because a rectangular signal has a spectrum width very large.



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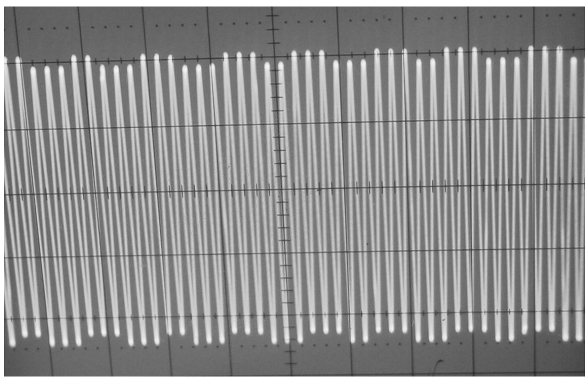

b)

Figure 4. Signal with rectangular variation

V. CONCLUSIONS

Using a sound card and relation (1) it can be build a very flexible virtual signal generator for flicker modeling, with a friendly graphical user interface, useful for study and analysis of this electromagnetic disturbance, which affect power quality. In contrast with simulated signals in Simulink or other software applications, it can be obtained real electrical signals. Their amplitudes are small enough and is safe to work while the signals from power supply networks have high amplitudes and are dangerous. To acquire such signals are necessary expensive conditioning circuits which for the virtual signal generator are not necessary.

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